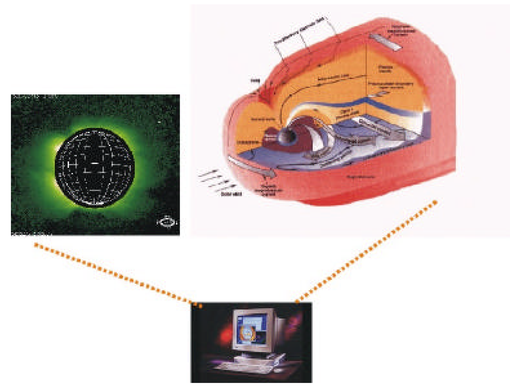

# The Community Coordinated Modeling Center (CCMC): Initial Results


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## Abstract


The Community Coordinated Modeling Center (CCMC) was established to facilitate the development, validation, and testing of space weather models. The first model selected for study at the CCMC is BATS-R-US, a 3D adaptive MHD model developed at the University of Michigan. BATS-R-US is used to model of the magnetosphere for space weather applications. The simulation results are presented using a newly developed object-oriented visualization tool and the CCMC web site. Directions of future development are also discussed.



**Keywords:** numerical modeling, solar wind/magnetosphere interactions, storms and substorms, numerical simulation studies


## Introduction

The **Community Coordinated Modeling Center** (**CCMC**) was established to facilitate the development, validation, and testing of space weather models. The CCMC will provide computer assets sufficient for developing and testing the largest and most sophisticated space weather models. The CCMC staff will support the integration of existing research grade models, as well as perform research in space plasma physics as required to further space weather goals. The CCMC will host visiting students and scientists as required during the model development and testing.

Participating agencies have all offered support for the CCMC including the purchase of computational assets, physical infrastructure for the center, scientific and technical support, and post-doctoral research support. Present plans call for an initial capability of 32 IBM SP2 processors at the Air Force Weather Agency (AFWA) in Omaha. The CCMC front-end computers and workstations will be at Goddard Space Flight Center (GSFC) with a high-speed data link between the two sites to ensure immediate and seamless operation of the center.

Selection of models for the CCMC will be based on their potential to contribute to operational space weather forecasting. Initially three models will be selected: an ionosphere/thermosphere model, a magnetosphere model, and a solar or solar wind model.

## BATS-R-US

The first model selected to be implemented at the CCMC is the Block Adaptive Tree Solar-wind Roe Upwind Scheme (BATS-R-US). BATS-R-US was developed by the Computational MHD group at the University of Michigan with support from the NASA High Performance Computing and Communications Earth and Space Sciences (HPCC ESS) project [Powell et al., 1999]. Key features of BATS-R-US are listed below:

- Solves the MHD equations in finite volume form using Roe's Approximate Riemann Solver [Powell, 1994],
- Implemented in FORTRAN 90 using the Message Passing Interface (MPI) standard,
- Uses block-based hierarchical data structure on a finite-volume Cartesian grid,
- Parallel adaptive mesh refinement (AMR) techniques automatically adapt the computational grid to the problem, and
- Refinement/coarsening done on the fly based on heuristically defined criteria.

## Initial Results

The BATS-R-US code is currently used for global MHD magnetospheric dynamics modeling. The CCMC staff has run BATS-R-US on a 32-node SP2 at Maui High Performance Computing Center (MHPCC). The robustness of BATS-R-US has been tested using a variety of inflowing solar wind parameters. The case presented in this poster considers the sudden flip of a northward IMF to a southward IMF and the dynamic response of the magnetosphere. The propagation of the magnetic field reversal sheet towards and past the Earth can be followed on the large scale. Focusing on the subsolar region we see the formation of the magnetopause current layer with reversed magnetic field. Results from this test case are shown in Figures 1 and 2. The next two sections discuss the CCMC tools used to visualize the simulation results.

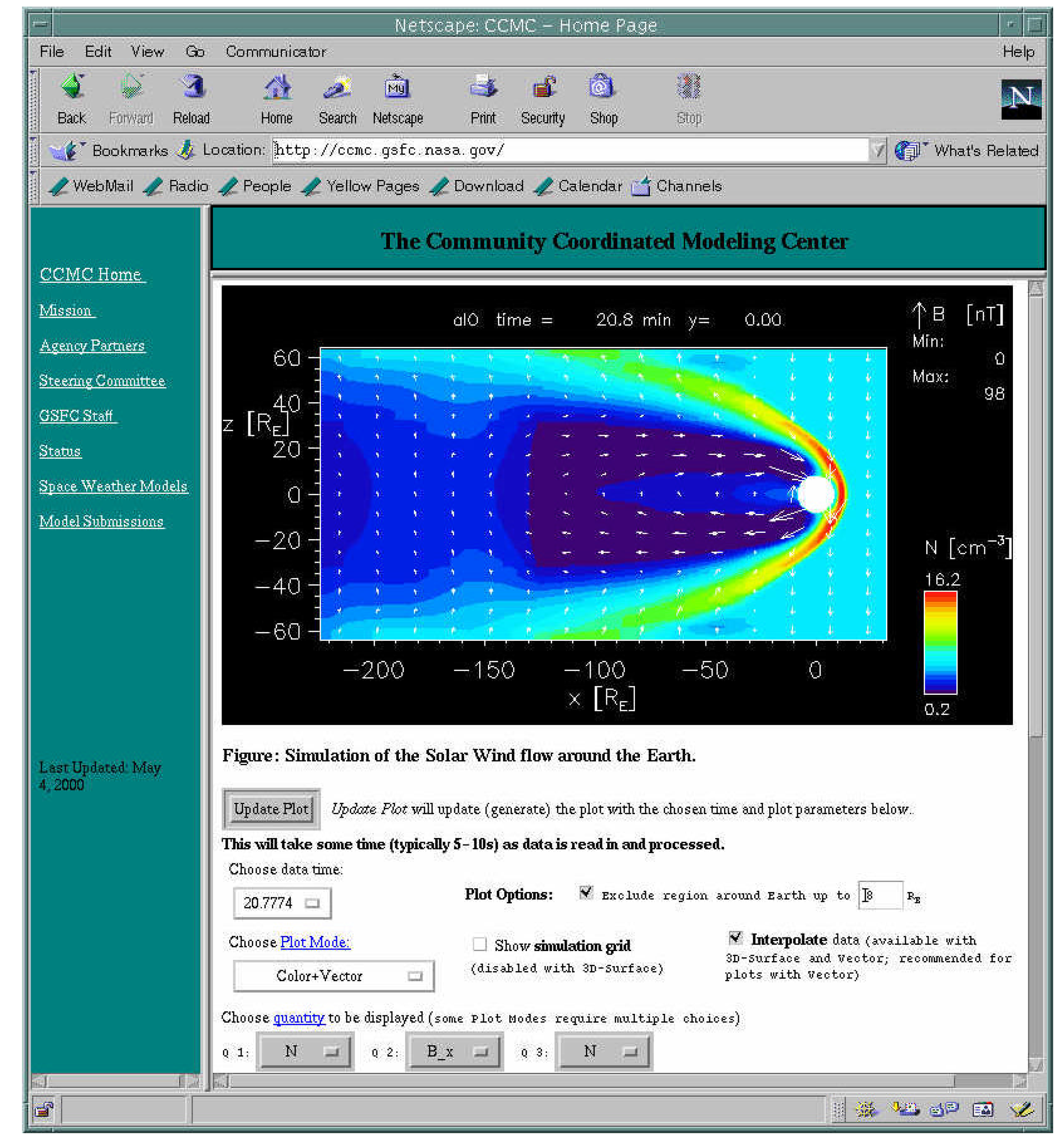


**Figure 1. CCMC Web Interface.** The density and the projection of the magnetic field in the *xz*-plane from our initial BATS-R-US run are displayed using the CCMC web interface. The CCMC web interface runs Space Physics Simulation Visualizer (SPSV) using a Perl script.

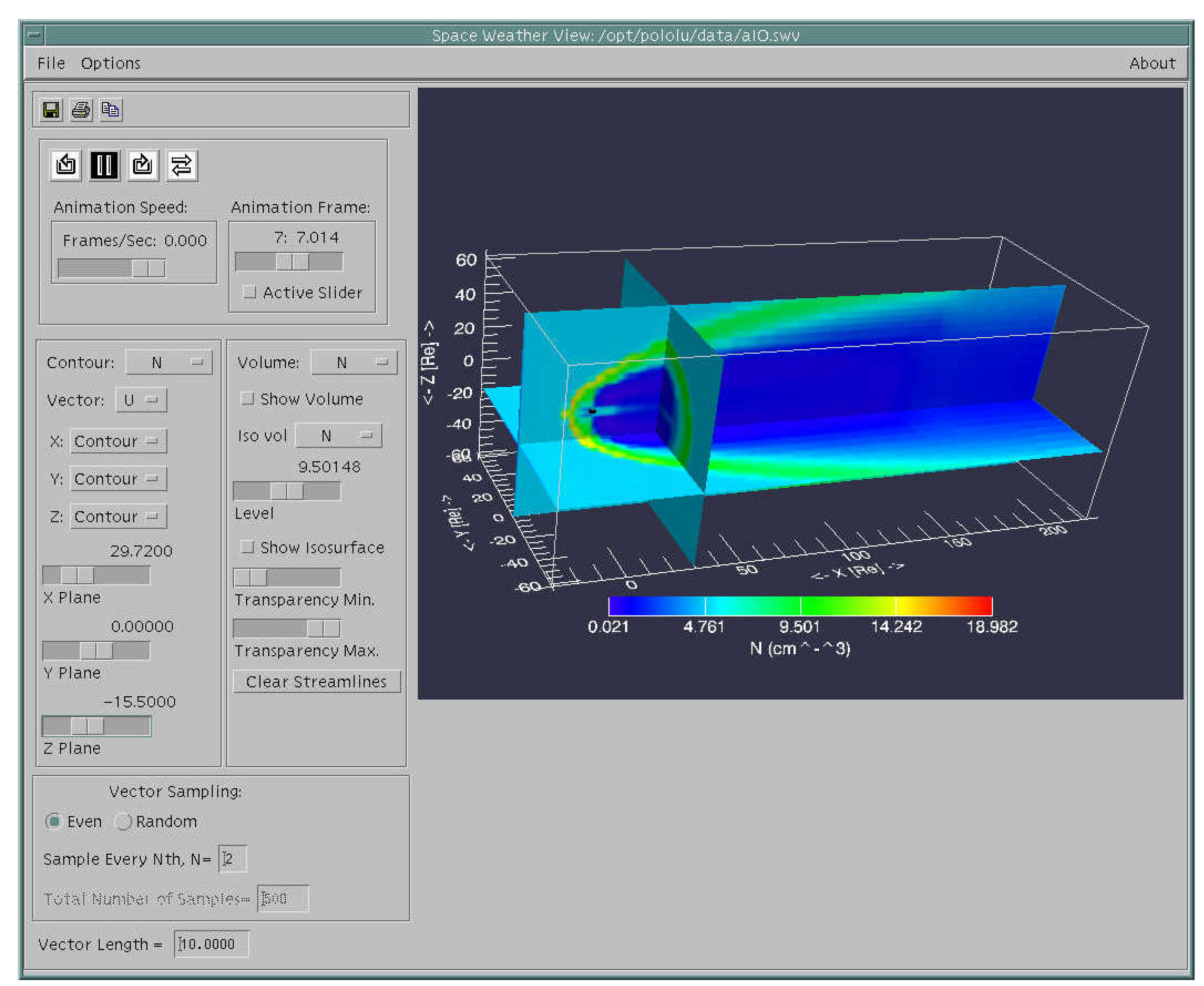


**Figure 2. Space Weather View (SWV).** The density from our initial BATS-R-US run is displayed on three 2D contour plots using SWV.

## Space Physics Simulation Visualizer (SPSV)

Space Physics Simulation Visualizer (SPSV) is an Interactive Data Language (IDL) program that enables the user to select from a myriad of display modes for 2D cuts through the 3D simulation volume. These modes include contour, vector, and flow lines. The user can also specify a subregion of the simulation volume enabling a more detailed view of interesting features. There is also an option for a 3D rendition that allows up to nine 2D color contour planes displayed in a 3D box along with the magnetic fieldlines. Additional options include display of the adaptive grid superimposed over the data, and the elimination of the near-Earth region with the strong dipole magnetic field.

The CCMC web interface shown in Figure 1 enables users to access model output data from remote locations. The user is able to enter display parameters on the HTML form. The form is pre-processed by a Perl script which calls SPSV. The SPSV returns a GIF image that is then displayed on the web page. The output data from the BATS-R-US MHD model is pre-processed to enable fast access to small spatial blocks for any given simulation time. This pre-processing enables the back-end program (SPSV) to typically create the returned image in 5 - 20 seconds.

## Space Weather View (SWV)

Space Weather View (SWV) is a newly developed object-oriented visualization tool that uses IDL object graphics to visualize in 3D output from space weather models. SWV originates from IDL's thunderstorm demo program and is illustrated in Figure 2. Currently SWV displays output from BATS-R-US which has been pre-processed onto a regular grid and quantized to byte data. In the future, SWV will be enhanced to display output from other space weather models accepted by the CCMC.

SWV is an interactive program providing great flexibility and usability. The user can intuitively rotate, scale or translate the view volume by dragging the mouse in the draw window. The user can view the entire volume, an isosurface and up to three cut-planes at a time. The cut-planes can either be a contour or vector plot and can be moved by dragging a slider. In addition, the user can view the same view parameters at different time steps by using the animation features of SWV.

## Future Work

In the future, the CCMC steering committee will select more models for implementation by the CCMC. The data visualization tools demonstrated by this poster will be enhanced to render the outputs of these models. The CCMC staff plans to run the models selected on specific events or science problems for the community's usage, and for code testing and verification. Currently the CCMC staff is developing a method for feeding satellite solar wind data into BATS-R-US. The CCMC staff is also working on interfacing BATS-R-US with Mei-Ching Fok's radiation belt model [Fok, 1999].

Another important future development is the software that will facilitate the inter-communication of different space weather models. The system will provide a graphical user interface to manage the execution of the integrated system and a toolbox of common reusable software applications such as data visualization modules and coordinate transforms. The system will be designed to permit seamless communication between the CCMC front-end at GSFC and the cluster of IBM SP2 nodes at AFWA. The system will also be designed to allow swapping of modules to enable flexibility in integration of newly developed modules.

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